CHAPTER 8

Darwinian Archaeologies

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> It may be that the next great developments in the social sciences will come not from professed social scientists but from people trained in other fields.
>
> —George Lundberg, *Foundations of Sociology*

A vital notion for all historical sciences, the term "evolution" has a myriad of meanings and definitions that form the basis of explanations and evoke a range of reactions from advocates and critics. In general, however, the term basically refers to change. In this innocuous sense, most archaeologists would likely consider themselves as evolutionists as the archaeological record is, by its nature, a record of change. In fact, one of the primary reasons we study the archaeological record is because what exists today is different from that of the past and thus archaeology is the study of that change. It is conceivable that few archaeologists would argue that the discipline is evolutionary if the word "evolution" is limited to this basic connotation.

While there is little controversy about evolution as change, explaining change is another matter entirely, and in this sense the topic of evolution provokes the great emotion among proponents with different notions of what evolution means. It is useful, then, to delineate a series of technical meanings for the concept of evolution that are helpful to distinguish the various explanatory frameworks that that the word connotes.

EVOLUTION AS TRANSFORMATION

The first meaning is one that invokes the idea of transformation. Indeed, its etymology traces back to seventeenth-century roots as a word that means "to unfold, open out, expand." The general concept here is one of transformation that occurs due to innate properties and internal activities. In this sense of evolution, two factors are commonly identified as the source of these transformations: the direct influence of the environment, through an inheritance of acquired characters and an intrinsic drive toward a definite goal, particularly toward greater perfection (Mayr 2001:77).

The first factor, the environment, centers on the notion that the external world makes things change, but it does not specify how, which is one reason why evolution is sometimes confused with environmental determinism. The acquired characters factor was initially proposed by Jean-Baptiste Lamarck (1744–1829) to be the engine behind evolution. Lamarckian evolution states that change occurs because entities pass on traits to their offspring that they acquire during their lifetimes.

The intrinsic drive related to a goal is one of the most commonly invoked mechanisms for transformational evolution and is related to change in the form of development (Carneiro 2003). Here evolution is considered to be change that is directional, a direction that is often associated with progress (Dunnell 1988). While occasionally invoked in biology (Niteki 1988; Ruse 1997), this finds predominate usage in various forms of cultural evolution, which holds that human populations transform themselves, progressing measurably along a yardstick of progress that is often referred to as complexity (Carneiro 2003).

Cultural evolution in anthropology dates to the nineteenth century (Morgan 1877; Spencer 1887; Tylor 1865). During much of the twentieth century, cultural evolution was largely a European concept (Childe 1944; Figuier 1870; Peake 1928) and was rejected by the majority of Americanist anthropologists (Holmes 1892). It was revitalized in the 1960s, however, through the work of Leslie White (1959). As a result of this revitalization and New Archaeology's interest in developing explicit frameworks for explaining change, cultural evolution emerged to form many of the underlying principles of contemporary archaeological explanations (Binford 1968; Flannery 1972, 1986; Kirch 1990; Sahlins and Service 1960; Service 1975; Spencer 1990; Wright 1986; Yoffee and Cowgill 1992). Cultural evolution approaches assume that change occurs due to responses by past populations, whether that is labeled as an adaptation to some stimulus (Binford 1968; Boserup 1965; Carneiro 1970; Cohen 1977; Flannery 1972; Kirch 1980) or, more recently, agency in which change occurs due to the internal actions of individuals within a population in response to perceived states in the environment (Dobres and Robb 2005; Pauketat 2001; see Gardner, chapter 7).

EVOLUTION AS CHANGE IN VARIABILITY

The forms of cultural evolution just described are quite distinct from the notion of evolution that underlies biology and is the basis of evolutionary approaches to archaeology and anthropology. This kind of evolution is often recognized as Darwinian evolution due to its origins. The confusing part is that on the surface, explanations made using cultural and Darwinian evolution take a similar form. Darwinian evolutionary explanations explore "any net directional change or cumulative change in the characteristics of organisms and populations over many generations" (Endler 1986:5). This basic definition for Darwinian evolution is remarkably similar to the transformation notion of evolution: both treat change as directional.

The Darwinian definition, however, belies two of the basic tenets of biological evolution. The first tenet of Darwinian evolution is that variation is causal. At any point in time, things vary with respect to each other, and this variability produces change. Variation is causal because the interaction between variability and the external world produces differential success. So we explain change due to the details of that variability—how one variant is different than another. The second tenet of Darwinian evolution is that the mechanism of change is external to the things that we are explaining; change results from the interaction of entities with the external environment and/or with other entities. What is seen as the external selective environment and what is selected is the source of much of debate, as discussed in this chapter—should we consider humans as being selected by their environment, artifacts as selected by humans, or even humans selected by their artifacts or environments modified by humans? Because various approaches differ in their emphases (table 8.1), this leads to a fascinating, almost philosophical debate over human intentionality, as discussed below.

Table 8.1. Dimensions of Variability in Evolutionary Approaches

Dimension	*Variability*
Temporal scale	Long <-> Short
Variation	Artifacts <->Behavio <-> Ideas (Memes)
Transmission	Vertical <->Horizontal
Subject and object of selection (Intentionality)	Humans <-> Artifacts <-> Environment
Sorting mechanisms	Natural selection, transmission, drift, phenotypic plasticity

In any case, once these subjects and objects are identified, the tenets above form the basic foundation of Darwinian evolution in which change is explained as the result of a two-step process. First, variability exists. Second, some portion of that variability persists, some does not. While that may be agreed on, the million-dollar question is how and why do some things persist and become more common at the expense of others? While natural selection—the differential persistence of certain traits over others—is usually the null hypothesis in biology, when explaining change in human culture the answer is prone to debate (often heated) in almost every case. Other chapters in this handbook describe other mechanisms for evolutionary change, such as drift (see Collard et al., chapter 13) or self-organization (see Bentley and Maschner, chapter 15), and there much debate over when and where natural selection predominates in the process of culture change (see Collard et al., chapter 13; Gabora, chapter 17). However, there can be no doubt at least that on some time scale (e.g., our evolution from australopithecines) that natural selection has acted. Hence a chapter on evolutionary approaches needs to define natural selection. The differential persistence of entities can be explained as the result of natural selection for evolution of trait T if and only if:

1. Entities vary with respect to T (VARIABILITY)
   and
2. Different variants of T confer differing probabilities of survival and/or replication on the entities. (FITNESS)
   and
3. Entities transmit their variants of T with better-than-chance fidelity through successive replications. (INHERITANCE)

Based on this definition, one can readily appreciate how natural selection is different than a transformational type of evolution in which entities change themselves. Natural selection is not an event per se, but an explanation of a statistical outcome in which variability has been differentially sorted. Natural selection simply explains the distribution of entities in time and across space. Second, evolution is what one might consider a mechanistic explanation, in that the entities provide just the materials (variability) on which change acts. Third, rate of change is not specified. Although evolution is often thought to be gradual, nothing in the theory requires this. Evolution by natural selection may result in change or stabilization, and can be fast or slow. Finally, natural selection does not need to be a result of nature—the natural environment—as our own minds and the minds of other people are also a highly selective environment for ideas and behaviors (see Gabora, chapter 17).

Finally, as variants are passed on from entity to entity, natural selection requires that different variants vary in how they affect the degree of persistence of entities. This is what is meant by the concept of fitness—how well any particular variant (the definition of the variant often being half the challenge) persists relative to others. Natural selection (and the notion of fitness) does not require any particular empirical event such as death or even birth for it to be invoked as part of an explanation. Although often associated with these when it comes to understanding biological change, the definition of natural selection is silent with respect to how variation in persistence occurs, that is, whether variant frequencies change in accordance to how they differentially replicate or differentially survive. This means that two different researchers might choose different descriptions for the same thing—one might describe some behavior that spreads relative to another, whereas another would refer to selection of one behavior over another. Neither has said anything yet about why one behavior gained frequency over another, which is important to recognize, so that one can go on investigating the phenomenon rather than get tangled up in debates over semantics!

EVOLUTION IN ANTHROPOLOGY AND ARCHAEOLOGY

When generally framed, the integration of evolutionary principles into social anthropology and archaeology requires only minor reconceptualization of replication. Although we are most familiar with biological entities that pass on information through the physical expression of genes, evolution is not restricted to just biology. The first recognized means by which variability is transmitted and the best studied is genetics. Genes are the units we give to information passed on between entities during biological replication. Genes, however, are not the only means by which variability can be passed between entities. Since no particular transmission is specified in Darwinian evolution, other kinds of mechanisms are possible. Consequently, it is now understood that culture constitutes a second (in addition to genes) mechanism by which inheritance occurs. The inheritance of culture (cultural transmission) was specifically introduced to account for variability and similarity in behavioral traits, as opposed to morphological traits in animals (Bonner 1980).

The transmission of nongenetic information between individuals surprisingly common among organisms and is not limited to humans. Accumulating empirical evidence shows that animal behaviors are often passed on between individuals and are independent of genetic or environmental changes (Bonner 1980; Heyes and Galef 1996; McGrew 1992; Nishida 1986; Rendell and Whitehead 2001). Biologists have recorded instances of cultural inheritance among dolphins (Krützen et al. 2005), orca whales (Ford 1991), primates (Biro et al. 2003), elephants (Poole et al. 2005), fish (Brown and Laland 2003), and birds (Fritz and Kotraschal 1999; Grant and Grant 1996; Lynch 1996). Although many early models of cultural transmission were based largely on analogies derived from genetics (Boyd and Richerson 1985; Cavalli-Sforza and Feldman 1981), more recent models have considered the characters of cultural transmission that involve the continuous inheritance and acquisition of information without empirically definable generations (Bettinger and Eerkens 1999; Lipo et al. 1997; Neff 2001; Neiman 1995; Shennan and Wilkinson 2001). Discussion continues about the degree to which biological models can be used to explain cultural variability, both pro (Collard and Shennan 2000; Shennan and Collard 2005) and con (Terrell 1988; Terrell et al. 1997; Welsh et al. 1992).

Given the expansion of evolutionary theory to include the explanation of cultural variability, there is clear potential for evolutionary approaches in archaeology. Despite this potential, archaeologists and anthropologists disagree about the role and the degree to which processes of Darwinian evolution structure human behavior and the archaeological record (Maschner and Mithen 1996). Consequently, the integration of Darwinian evolution into archaeological explanation takes place under a variety of schools that we identify here as dual inheritance theory (DIT), evolutionary archaeology (EA), human behavioral ecology (HBE), evolutionary psychology (EP), and cooperation and multilevel selection (CMS). While some of these approaches are often portrayed as competitive (Boone and Smith 1998), these schools are conceptually overlapping and all are founded on principles based in Darwinian evolution (table 8.1). Each varies substantially, however, in the way in which evolution is evoked as parts of explanation.

DUAL INHERITANCE THEORY

Boyd and Richerson (1985) were primarily responsible for the initial development of DIT (see Collard et al., chapter 13). DIT holds that the variation, inheritance, and natural selection of cultural traits are correlated, but as a distinct process from human genetic evolution. The focus of DIT is that unlike genetic information, cultural information is constantly passed between unrelated people. Interested in how genes and culture coevolve, Lumsden and Wilson (1981) envisioned cycles in which the individual is exposed to culturgens (parcels of culture) throughout life, rejecting, retaining, and incorporating new culturgens according to their genetic leash, or genetically based predilections to adopt certain behaviors while filtering out others. Each generation, most of these culturgens and epigenetic rules were recycled, but with small modifications guided by natural selection over many generations. One of the basic principles of DIT is that cultural evolution is a distinct, independent yet related process to biological evolution. This is the approach of Durham (1991: 26), whose version of what these different systems involve is summarized in table 8.2.

One of the issues of DIT is to evaluate the relative effects of horizontal transmission (between genetically unrelated people) from vertical transmission (from older to younger genetic relations) in cultural evolution. While vertical transmission appears to be the predominant path for the social learning of traditional craft skills (Heyes and Galef 1996; Shennan and Steele 1999; Avital and Jablonka 2000), the effects of horizontal transmission can be dramatic, as cultural traits can spread from one to one, one to many, many to one, or anything in between. As discussed in detail by Collard et al. (chapter 13), these forms of transmission can be biased in a variety of ways, such as toward prestigious individuals, through conformity, through novelty, and so on.

One of the contributions of DIT to the study of the archaeological record is the recognition of the significant role that horizontal transmission in a variety of forms has in modeling human social and cultural evolution (Ames 1996; Shennan 2002). Neiman (1995) adapted the neutral-trait model from population genetics (Crow and Kimura 1970) to illustrate cultural drift by assuming perfect neutrality. In that a person is only as likely to copy his or her own variant as to copy anyone else's. Bentley and Shennan (2003) propose that unbiased transmission (drift) inevitably results in a highly skewed distribution in the frequencies of a certain stylistic trait, meaning that a few highly popular styles can be expected to emerge over time. The neutral-trait model is remarkably powerful as a null hypothesis, allowing archaeologists to determine when other forces are acting in material culture evolution (Shennan and Wilkinson 2001). The ways in which the variation in an archaeological assemblage differs from the predictions of the neutral-trait model may be explained by natural selection and transmission processes reduce or increase variation. Future studies may be used to explain how variability is transmitted across stylistic and functional dimensions (Neff 1993) in areas such as communication (Wobst 1977) and artifact manufacture process (Dietler and Herbich 1998).

One significant aspect of DIT is the independence that is maintained between cultural and biological evolution. One extreme version of this independence is memetics (Pulliam and Dunford 1980; Bloom 1995; Brodie 1995; Dennett 1995, 1998; Lynch 1996; Barkow 1989; Durham 1991). Dawkins (1976) proposed memes as transmissible parcels of culture, which replicate themselves like viruses and thus allow population genetics to be applied to cultural evolution. Seeing cultural phenomena spreading like viruses (Cullen 2000) is fairly intuitive to most in the modern world of fast-spreading fads, chain-letter e-mails, and trendy

Table 8.2. Differences in Biological versus Cultural Evolution

Evolutionary Component	*Biological Evolution*	*Cultural Evolution*
Units of	Genes	Memes
Sources of variation	Mutation, recombination, migration	Innovation, synthesis, migration, diffusion.
Mechanisms of inheritance	Biological reproduction. Vertical, two parents with one or more offspring	Communication. Vertical, horizontal, and oblique transmission. One "parent" variable offspring.
Mechanisms of change	Mutation, migration, drift, natural selection	Frequency dependence, innovation, migration, diffusion, drift, cultural . selection, natural selection, cultural and social differences in transmission

Source: After Durham 1991:table 8.1.

phrases like "watch this space" that we find ourselves using without always knowing where we acquired it. Memes such as these spread horizontally and take less than a human generation to spread and often fade away. As mentioned above, Lumsden and Wilson (1981:27) used the term "culturgen," and many other definitions (and names) for a cultural replicator have been proposed (Blum 1963; Cavalli-Sforza and Feldman 1981; Swanson 1973; Boyd and Richerson 1985; Cullen 2000).

Proponents argue that the advantage of memetics lies in taking a "meme's-eye" view (Dennett 1998), that is, to consider memes competing with each other in human brains (Dawkins 1976:211), which could explain why some of our behaviors are maladaptive. Ball (1984) listed four possibilities: (1) the meme helps itself and the host in replication, as in the idea of sex; (2) the meme is healthy for the host but not particularly heritable by itself, as in the idea of walking rather than driving to work in a commuter population; (3) a highly heritable meme that is bad for the host, such as cigarette smoking; and (4) although arguably rare, memes that are maladaptive for both the host and the meme itself. A commonly cited example of the latter is the endo-cannibalism (eating the flesh of deceased relatives) among the Fore of Papua New Guinea, which caused a disease called Kuru (Barkow 1989; Cronk 1999).

Although evolutionary in structure, memetics offers a framework for studying properties of cultural evolution that give it its particular form and structure (Lake 1998). Genetic evolution involves the differential reproductive success of genes that are transmitted in discrete events as physical chemical packages and that express themselves in the building of individual organisms from the encoded genotype (Dawkins 1976). Memes, however, are simply information transmission and produce any scale of phenomena from individual features to entire reproducing entities. In this way, memes have the potential to be cumulative and inherit the qualities of preceding and contemporaneous ones (Jablonka 2000). Science, for example, works this way as the process builds on the results and successful explanations of predecessors (Bentley and Maschner 2000; Hull 1988). The same goes for the definition of meme, which has changed from that of Dawkins (1976) to Ball (1984) to Durham (1991) to Lake (1998) to the current discussion.

While we see that taking a meme's-eye view can be quite useful, it is important not to carry the approach to the extreme, where human minds become passive vessels for memes (Blackmore 1998). At the very least, it can be said that memes do not compete on a blank slate because human culture and the brain act as filters and modifiers of memes (Ball 1984; Barkow 1989; Cronk 1999; Lake 1998; Lumsden and Wilson 1981; Sperber 1996). This raises the important point that one cannot have a theory for sociocultural change without specifying what actually changes and what the units are (Bronowski 1977; Dunnell 1978; Plotkin 1994). Henrich and Boyd (2002) argue, however, that while mental representations are imperfect replicators at the individual level, they can still be accurate replicators at the population level. In any case, the only way to know what the useful cultural units are is to measure their replicative success over time (Pocklington and Best 1997; Lipo and Madsen 2001; Leonard 1998; Lyman and O'Brien 2001).

EVOLUTIONARY ARCHAEOLOGY

Evolutionary archaeology (EA) offers a paradigm for the explanation of the archaeological record based directly on the foundations of Darwinian evolution. Proponents of EA argue that archaeologists have much to gain from employing the theoretical framework that has been developed in evolution, specifically the concepts of natural selection and inheritance (Dunnell 1980). In fact, EAs see the lack of such a unified conceptual frameworks as one of the primary causes of the failure of the social sciences as a whole to live up to their promise (Sellars 1963; Rosenberg 1980). Thus EA is largely the product of a concerted effort to make use of explicit, falsifiable hypotheses generated from theory in the construction of explanations of the archaeological record (Dunnell 1982, 1992, 1989b).

EA identifies one of its largest challenges as adapting biological concepts into versions that can account for cultural variability (Dunnell 1995; Leonard and Jones 1987; Teltser 1995). In EA, this challenge is addressed by constructing measurement units that track frequencies of heritable traits of artifacts through time and across space, and to explain them in terms of transmission processes and the differential reproductive success brought about through natural selection, drift, and sorting. In this way, EA overlaps substantially with DIT but tends to focus on the evolution of biological and cultural variability as a single integrated explanatory system rather than distinct theoretical components. Part of the reason for this kind of explanatory framework is the conceptualization of what EA attempts to explain. EA is distinct in its focus on the archaeological record as the subject of explanation, rather than behavior, people, the "past," or any other phenomena not directly observable. When criticized for this (Boone and Smith 1998; Schiffer 1996), EAs reply that their focus is consistent with a model of science that uses concepts to account for empirical measurements (Eddington 1953; Lipo 2001; Sellars 1963).

Phenotype-Genotype

EA proponents stress the construction of appropriate units for measuring and explaining variability in the archaeological record. In biology, the standard means of measuring variability is to distinguish the genotype—the genetic instructions for replicating an organism—from the phenotype—the physical expression of those instructions. These units can obviously be used to account for the inheritance and construction of human biological features (hair color, build, eye color, etc.). The crux of this argument is that EAs argue that these units can also account for human artifacts and behavior, which of course are not produced by solely by genes. Understanding cultural transmission in the archaeological record requires analytical units that represent how it affected artifact manufacture, morphology, and use and deposition. EAs use this framework to establish artifacts as an additional part of our phenotype (Dunnell 1989; Leonard and Jones 1987). The original discussion by Dunnell (1980), that the extended human phenotype includes tools in the same way that a bird phenotype includes its nest, created a storm of controversy. Many readers understood the argument to be that artifacts were phenotypic exactly as bird's nests are, that is, without the key concept that a cultural genotype includes both cultural and genetic information. Critics (Boone and Smith 1998; Lake 1997; Larson 2000; Maschner 1998; Maschner and Patton 1996; see Gabora, chapter 17) pointed out that human cultural traits evolve much faster than human individuals or animal behaviors. In fact, EAs were not actually in disagreement with these undoubted realities (Madsen et al. 1999; Neff 2000). EAs have redefined the notions of phenotype and genotype to include all of the aspects of ourselves, including our bodies, behavior, and artifacts. This essentially resolves twenty years of miscommunication in which EAs were using the biological terms gene, genotype, and phenotype as conceptual tools, whereas critics assumed these terms carried the literal biological definitions (Cullen 2000).

EAs argue that their expanded, genetic-cultural view of the phenotype enables them to explain artifacts as a means by which individuals increase their fitness in their environment (now approaching similar domains in human behavioral ecology, discussed below) in a way that is empirically similar to the effect of spiders constructing webs or birds making nests. EAs do not dispute the distinction between human artifacts and spider webs and bird nests (see Gabora, chapter 17). The behaviors involved in nest and web construction are predominately genetically inherited, and birds and spiders can make a perfect nests and webs without ever having seen another one made (Dawkins 1982 and citations). Though these kinds of phenotypic extensions can vary in response to particular environments (i.e., are "plastic") and can be modified through individual learning, the modified behaviors are not transmitted because the genes that control it are not. As a result, the next generation starts with the same biological basis for behavior (albeit with changes as determined by genetic inheritance and mutation), but not the modified behavior. What distinguishes EA is its argument that human artifacts can be conceived as portions of phenotypes, even though much of human behavior is learned and transmitted in a continuous fashion—not constrained by biological reproduction.

Although using different definitions for phenotype, EA and DIT recognize that human behavior and material culture evolve through cultural and biological transmission, and both approaches seek to resolve these pathways of inheriting information, and to determine how they interact (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Dunnell 1978, 1980, 1989; Leonard and Jones 1987; Lyman and O'Brien 2001). In some cases, cultural transmission and biological reproduction can be viewed as distinct processes, such that the replicative success of cultural traits need not be associated with the reproductive success of the bearer. In other cases, the success of a cultural trait affects the differential biological reproduction of the people using it, such that the variable success of these individuals becomes critical to the reproductive success of the trait itself. In others, combinations of traits may be differentially replicating without clear impact to the biological success of the organisms involved in the replication procession.

The fact that cultural and biological reproduction is sometimes independent and sometimes entangled is a source of confusion in some recent debates. Boone and Smith (1998:S147), for example, argued that if culture changes only through natural selection on human individuals, then cultural change rates would be limited by human generation length. Although culture elements that are decoupled from human survival can change much faster than human generation times (e.g., cultural fashions), there are also many cases where the variable success of individuals who produce certain cultural traits is also critical (e.g., the spread of agriculture through dispersal of farming populations). In the latter case, success of cultural traits is tied to increases/decreases in relative frequencies of the people (i.e., changed in the number of biological organisms) who replicate the traits, which can change on timescales shorter than a generation.

Proponents of EA do not reject the notion that cultural traits can have fitness consequences for biological reproduction. Evolutionary archaeologists, however, go further to say that biological reproduction is not the only way in which traits can have fitness consequences. Thus, rather than limit natural selection to its effects on biology, EA often makes use of the inclusive term "replicative success" (Leonard and Jones 1987; Lyman and O'Brien 2001), which invokes the idea that traits can have potential benefits to replicating entities at higher scales (i.e., replicators). Relative to classes of vessels, a persistent set of attributes, for example, may convey replicative success (Neff 1993), while an Acheulean hand ax may have enhanced the sexual attractiveness of the males who carried it (Kohn and Mithen 1999). For EA, fitness is assessed at the level of traits and their relations to replicators, rather than strictly to biological individuals and their reproductive output. In this way, the debate over "artifacts as phenotype" is largely a semantic argument, involving the traditional biological definition of "phenotype" versus the EA redefinition of the term. In fact, the EA approach includes genetic and cultural inheritance and the potential for differential success as multiple scales of analyses.

Intentionality

A controversial aspect of EA is the role that human intention plays in constructing explanations of the archaeological record. Although intention seems to be an obvious part of causation (since we invoke it as part of our everyday explanations of human behavior), it is not a necessary component of evolutionary explanations. Dunnell (1989:37), for example, has argued that intention is as irrelevant to cultural evolution as oak tree intentions are to oak tree evolution. Much of the debate about EA centers on the meaning of such statements (Boone and Smith 1998), with the contention largely due to at least two distinct usages of the notion intention. The first usage is related to intention as an explanation. In the conventional view, intentionality is the assumed relations between mental acts and the external world. We view doctors, for example, as intending to contribute towards a cure for a patient, and we count them as successful in achieving those intentions if they do. Similarly, we can look at artifacts and think that prehistoric individuals intended to build monuments and tools. This form of intention is part of our cultural means for accounting for observations human behavior.

In contrast, EAs argue that intentionality used in this way is merely a manifestation of a cultural sense-making system, and thus more or less irrelevant to science. "Intention" as a cause is part of our own common sense: our culturally inherited way of understanding everyday experience and attributing human action with purpose (Dunnell 1982). Commonsense systems for causation are what we replace through development of science in the same way that physics and chemistry replaced "fire, earth, and water" as the basis for the world. Attributing intention as a cause is our explanation for the world (albeit cryptic and embedded in common sense). EAs argue that their approach is the way to build a scientific sense-making system that is explicit (i.e., has theory) and is falsifiable (i.e., that has an empirical standard for determining veracity). Since every culture, including our own, has its own sense-making system, this does not make our explanatory system privileged in any absolute sense. EAs maintain that even science is only a particular kind of sense-making system, which is effective with respect to the tasks that scientists set out to achieve (Eddington 1953; Sellars 1963; Wilson 1998).

Hence, whereas the more conventional view (i.e., transformation-based evolution) holds that purposeful intentionality is an empirical phenomenon that has produced the variability observed in the archaeological record, EA holds that human behavior is random with respect to natural selection through the evolutionary process of variation generation and then sorting of that variation (Leonard and Jones 1987; Rindos 1989). This does not mean that EA claims that people act randomly (which would be nonsense), but instead that intentions cannot themselves be an explanation for behavioral change because intentions are part of behavior, and therefore the subject of inheritance and natural selection of behavioral regularities.

In this way, the intentions themselves are also potentially subject to evolution. This actually holds much in common with evolutionary psychology and human behavioral ecology (see below) in that evolution has shaped human cognition and what we refer to as "common sense." In EA terms, the variability produced by structured inheritance and innovation systems are the subject of explanation and this variability, in turn, affects the differential success of the systems that generate them (i.e., the replicators). Although seemingly abstract, this argument boils down to the basics of evolution in which our interest is explaining the differential persistence of traits. EA focuses, therefore, on tracking artifact variability in form and distribution through time and across space as the result of a combination of innovation, inheritance, and sorting processes such as natural selection. Human behavior is certainly nonrandom and imbibed with intention, but EAs argue that this is only an observation of the fact that our behavior is strongly inherited (culturally and genetically) using systems that include the inheritance of traits as well the inheritance of grammar (i.e., rules for generating traits and additional rules). This is what is meant when EA proponents say the intention critique conflates the tempo and mode of evolution (Lyman and O'Brien 1998, 2001).

Applications of EA

Applications of EA involve explanations of variability in material culture observed in the archaeological record using models of transmission and natural selection. One way of explaining the record is to use stylistic and functional classes to account for variation observed time and across space. Dunnell (1978) originally introduced the concepts style and function into EA as a way of accounting for the behavior of culture historical types. He explained culture historical classes as measurement units that attend to stylistic variability, or variability that is predominately structured by transmission among populations. In the transmission of attributes in which fitness differences between variants are small, changes in relative frequencies are explicable as the result drift and random effects involved in transmission. (Bettinger and Eerkens 1997; Braun 1991; Dunnell 1978; Lipo et al. 1997; Lyman and O'Brien 2000; Neff 1993; Neiman 1995; O'Brien 1996; O'Brien and Holland 1990). Measurements made using functional classes, on the other hand, emphasize performance differences and thus are explicable via natural selection. While these two kinds of measures have been mistaken as empirical claims (Sackett 2003), their distinction is a product of the way in which we study the world, not properties of things. In this formulation, style and function are simply explanations for the behavior of certain kinds of classes that we use to measure the world in particular ways (Cochrane 2001). Consequently, stylistic classes do not imply that an entity being measured lacks fitness, but rather that we are measuring entities in ways that do not reflect fitness differences. Likewise, functional classes are measures of the archaeological record that we use to generate observations that we can explain using the concepts of fitness and natural selection.

For example, Allen (1995) accounted for the shape of the distal end of prehistoric Pacific fishhooks as the result of selection acting on functional variability because through this shape became larger on Pacific fishhooks and then stabilized, which was interpreted as selection. Feathers (1990; Dunnell and Feathers 1990) argued that changes in prehistoric ceramics in the Mississippi valley from sand to shell temper was due to selection operating on performance differences of materials in changing firing regimes.

In contrast, stylistic classes are used to measure variability controlled by transmission and drift. Neiman (1995), for example, showed that the changes in Woodland ceramics from Illinois over time were explicable largely as a function of transmission and neutral (i.e., nonselective) traits. Similarly, Lipo (2001) demonstrated that the stylistic classes composed of decorative elements on late prehistoric ceramics from the Mississippi River valley could be used to track the relative degree of transmission among populations across space (e.g., an evolutionary approach to diffusion). Studies of stylistic traits on fluted projectile points enabled O'Brien et al. (2001) to measure clade structure among prehistoric populations and track lineages of chipped stone technology in the southeastern United States. The same approach was used by Cochrane (2004) to track lineages of prehistoric ceramics in the Fiji islands.

Another set of phenomena that has been explored by EA is the distribution of what is often described as cultural elaboration. Cultural elaboration is observed in the archaeological as monuments, elaborate burial goods, art, mounds, and other artifacts that are not directly related to individual human reproduction. Originally explained via the concept of waste by Dunnell (1989), the model has been integrated into a general evolutionary process known as bet hedging (Allen 2004; Aranyosi 1999; Hamilton 1999; Kornbacher 1999; Kornbacher and Madsen 1999; Madsen et al. 1999; Sterling 1999). The model defines cultural elaboration as the product of selection that favors reduced rates of reproduction when subsistence resources are unpredictable (Dunnell 1989, 1999) given that, under conditions of high variance, the fittest strategy is not always the one involving the greatest number of offspring, given the costs of birth and postnatal support (Seger and Brockman 1987). When resources are unpredictable, any behavior that reduces variance can potentially increase long-term reproductive productivity and will be favored by natural selection. While there are a variety of means of individually achieving reduced reproduction rates, including birth spacing and parental investment, a population-level means can be through energy invested in cultural elaboration. In this way, cultural elaboration would be expected to occur in periods of high variance in subsistence-related resources (Hamilton 1999; Kornbacher 1999; Madsen et al. 1999; Sterling 1999), or spatially along variable margins of productive environments (Allen 2004; Aranyosi 1999; Dunnell 1999; Dunnell and Greenlee 1999; Madsen et al. 1999:253–254).

While the bet hedging model potentially accounts for a wide range of cultural elaboration for variance reduction in unpredictable environments, this is hardly the only evolutionary account available—and it certainly is far from a complete explanation of all aspects of cultural elaboration. First, since we are studying historical phenomena, we must recognize that there are many evolutionary solutions to variance reduction and not all result in cultural elaboration that is visible in the archaeological record, or cultural elaboration at all. Alternative though lower ranked subsistence resources, for example, may be available. Fertility may be controlled through differential parental investment (Lack 1954; Mace 1996), a situation that has been observed in small mobile population such as the !Kung San (Blurton Jones 1987). Human behavioral ecologists (discussed below) often discuss the demographic transition, which refers to the apparent paradox that wealthy societies often have lower birth rates, but which is probably due to the increased investment that parents in developed countries must make in their children (e.g., for education), such that they cannot afford to have as many children—this is actually quite similar to the bet hedging explanation. Mobility is also a possible solution to environmental unpredictability (Madsen et al. 1999; Núñez et al. 2002; Polyak and Asmerom 2001). Second, not all observed instances of cultural elaboration must be explained as the result of bet hedging. Investment in architecture and monuments, for example, can be driven by changes in functional organization among populations (Wenke 1981). The cessation of monument construction seen at the end of the Akkadian, Classic Maya, and Tiwanaku empires (Binford et al. 1997; de Menocal 2001; Gill 2000; Weiss et al. 1993) are more likely attributable changes in the scale of functional organization.

Third, part of the constraints being placed on cultural elaboration may be related to models advocated by Boone (1998) and Neiman (1997)—models based on Zahavi and Zahavi's (1997) handicap principle and the field of signaling theory. Models based on signaling theory are not necessarily alternatives to the bet hedging hypothesis but provide additional explanatory component. Costly signaling is one mechanism which may link elaboration to reproductive effort—and may explain why the expression of cultural elaboration consistently takes similar forms. Costly signaling and the dynamics of bet hedging in variable environments are compatible, rather than competing, explanations—and each provides complementary and supplementary explanations of cultural elaboration—attending to different aspects of the record: distribution, intensity, form, and rate of change.

Finally, the explanation of the evolution of bet hedging may require accounting for group-level phenomenon. While bet hedging provides a means explaining cultural elaboration solely at the individual level, this can be insufficient for situations in which expressions of cultural elaboration involve cooperative, group-level activities, rather than just sorting of the actions of individuals within a population. An excellent example is the construction of large burial mounds. While many mounds were constructed over considerable spans of time, most archaeologists would agree that at any point in time, mounds and mound complexes were not the work of single individuals. It is likely that in many cases burial mounds were the work of communities, working in concert. If so, we must evaluate the possibility that cultural elaboration on the part of an entire group, working in a coordinated fashion, may have fitness benefits both to individuals and to groups of which they are members.

HUMAN BEHAVIORAL ECOLOGY

In anthropology and archaeology, the use of behavioral ecology is an outgrowth of Steward's (1955) cultural ecology as well as evolutionary ecology, which is the study of how evolutionarily adaptive designs perform in ecological contexts. Human behavioral ecology (HBE) is evolutionary ecology applied to human behavior (Krebs and Davies 1997; Winterhalder and Smith 1992, 1999). HBE holds that diversity in human behavior results from result of selection which has shaped our ability to adapt to diverse social and ecological environments (see Yesner, chapter 4). In HBE, human culture and behavior are forms of phenotypic plasticity that allows humans to adapt to different social environmental and ecological conditions (Boone and Smith 1998; Smith 1991; Smith and Winterhalder 1992; Winterhalder and Smith 1999). In other words, natural selection has resulted in a set of decision rules (Krebs 1978) rather than particular behaviors themselves. A decision rule follows a form such as, "in situation A, do X, in situation B, do Y, all other cases do Z" (Winterhalder 2002). A nonbehavioral example is the tanning response: If sunlight is intense, make skin darker color. If not, keep skin at its normal color. HBE argues that through flexible, goal-directed behavior, human cultural evolution often short-circuits natural selection (Boone and Smith 1998), and as a result cultural behaviors often evolve toward economically optimal strategies. A behavioral example occurred upon the decline of big game during the North American Archaic, when humans chose the more optimal strategy of hunting small game and foraging (Boone and Smith 1998).

Critics of HBE argue that the emphasis on adaptation effectively makes the approach equivalent to cultural evolution—evolution built on transformation. Neff (2000) argues that behavioral flexibility could not evolve because most new cultural traits are unique to human evolution, and therefore cannot be part of an evolved package of behavioral choices. In HBE, however, behavioral flexibility itself is the adaptation rather than the specific behaviors themselves. For this reason, HBE places much more emphasis than EA on the effect of human agency in cultural evolution, which allows culture to change much more rapidly than biological evolution. Hence HBE often treats culture as a relatively minor extension of biological evolution and that culture does not have any cumulative consequences (Flinn 1997; Boone and Smith 1998).

The Phenotypic Gambit

Like any science, HBE rests on assumptions in order to make its claims. One of the most basic and characteristic principle of HBE is what is commonly called the phenotypic gambit (Barrett, Dunbar, and Lycett 2002; Shennan 2002; Smith and Winterhalder 1992). This refers to the thesis that, as Shennan puts it "with few exceptions, little is known about the way in which specific behaviours are influenced by genes, because there are likely to be many genes involved and the interactions between them and the environments in which they are expressed are complex" (Shennan 2002:23). Taking this into account, people involved in HBE do not concern themselves with past evolutionary processes or with units of transmission nearly as much as those involved with DIT, EA, or EP do. They instead take current levels of fitness for adaptive strategies as proxy measures for accessing the evolution of those strategies. This causes behavior and not genes to be the primary level of analysis. This is also a primary criticism that EP and EA have of HBE but also marks what may be the best place for these different positions to be of use to each other. As Barret, Dunbar, and Lycett (2002) point out, HBE will be nothing but aided by linking their level of analysis with models generated by EP which is concerned with exactly what HBE isn't (discussed below). Smith and Winterhalder (1992) tell us that the phenotypic gambit stems from another assumption: extreme phenotypic plasticity.

Mary Jane West-Eberhard defines phenotypic plasticity as "the ability of an organism to react to an environmental input with change in form, state, movement or rate of activity" (West-Eberhard 2003:34). There are numerous ways that plasticity can come about, including multiple expressions from a particular genetic combination and individual learning. Phenotypic plasticity also may affect phylogenic evolution in several ways, including one famous example, the Baldwin effect as described by Daniel Dennett (1991, 1995). HBE utilizes phenotypic plasticity in at least two ways, first, with the idea of variation of behavior and, second, with the related concept of rational choice—the ability for individuals to make choices which fundamentally alter their fitness. This, in turn, leads to the primary methods utilized by proponents of HBE, optimal foraging theory (described below). It also leads to discussions on different levels or scales of analysis and the possibility of group level selection (also discussed below).

Rational Choice

HBE is partially predicated on the idea that humans are capable of making decisions about what sorts of strategies should be used in particular situations and that humans will attempt to optimize these strategies to fit whatever necessity there is. Given rational choice, energy expenditure or time expenditure or, in many cases, both, HBE assumes that there is an optimal way of doing this or that (Smith 1995). Rational choice is too similar to the concept of free will for some scholars is seen either as a different process working on evolution or as something ephemeral and possibly epiphenomenal. Thankfully, the philosopher Daniel Dennett (1992, 1995, 1996, and 2003) has developed a body of work attempting to conceptualize how something like rational choice can be fit into a Darwinian perspective without appealing to nonphysical or epiphenomenal causes.

Dennett's approach to this "problem" is a combination of Wittgenstein and universal Darwinism. He argues that many of the issues with free will are just problems with our use of language (1996). For the rest, Dennett proposes a universal view of Darwinism that situates the individual among many different influences each operating as part of a Darwinian system. Free will in this conception is not only misunderstood by being called such but is also the product of natural selection and a system of natural selection in its own right (2003). Dennett and other amenable philosophers allow HBE molders (and the rest of us) the ability to continue our work without the need to brush up against these philosophical topics and to link different forms of natural selection into a manageable model.

Optimal Foraging Theory

Optimal foraging theory (OFT), much like the claims of evolutionary archaeology, is founded in its empirical dimensions and the ability to create testable hypotheses about behavioral phenomena. OFT is founded on decades of ecological investigations on a range of species that have shown that individuals tend to maximize their foraging return in relation to the costs of foraging. OFT predicts that, all things being equal, humans consistently weigh the benefits versus costs of their future actions, tending to make decisions that maximize a particular variable, or currency (Stephens and Krebs 1986; Winterhalder and Smith 1981; Jochim 1981). Currencies include energy, information, time, technology, and risk, all of which can be used as the currency to be maximized (or minimized in the case of risk). It is often assumed with OFT that foragers use strategies with the maximum acquisition rate of food calories. In this case, all other variables, which can be estimated through ethnographic and other means, are assumed to be constant constraints in foragers' choices. For example, the choice of fishing strategy would be the one that harvests the most calories (the currency) in two weeks using nets, with a limited knowledge of salmon spawning behavior and no more than a certain amount of personal risk seen as the constraints. Such a situation can be modeled with classical economic equations, which are solved to find the strategy that produces the most calories.

Some of this makes common sense in that, all things equal and given the choice, one would probably choose to spend two hours to harvest one caribou rather than spending two weeks harvesting four hundred lemmings that have a combined meat weight equal to that of the caribou. Simple trade-off models like this, however, do not necessarily correspond with observed human behavior. Jochim (1981) wondered why the Cree would spend ten hours hunting a beaver in the spring when they could harvest a caribou in two hours. The failure to take into account choice, preference, or in this case fat content, might lead to some inaccurate conclusions. This is the reason most evolutionary ecologists use OFT as a screen onto which to project the actual data, using the deviations from optimality as a means of understanding cultural variations.

In the nonhuman world, assuming that an individual would, for the most part, maximize energy or some other factor when foraging is not unique or even interesting. It is a basic facet of animal ecology. But among humans it is certainly complicated by social interactions. One of the major realizations of recent social and economic research is that interactions between people are at least as important as objective constants defined with respect to an external environment (Hull 1988; Lake 1998), which profoundly questions whether rational choice, utility maximization, and optimal behavior are even valid assumptions (Keen 2003; Ormerod 1998, 2005; see Bentley and Maschner, chapter 15). New approaches (see Costopolous, chapter 16) suggest that more reasonable models are found in bounded rationality (Aurthur 1999)—a limited, local view of its environment, rather than an unrealistic, omniscient knowledge that is often assumed in OFT.

HBE appears to work best in small, mobile foraging groups with relatively simple goals (Winterhalder and Smith 1981) because under these conditions, any evolved adaptation for measuring foraging costs takes precedent over the social problems faced by more complex societies (see the next section). The more complex a society becomes, the more difficult it gets to make energy-maximizing choices, when many interacting specialists with different goals are reacting to each other's actions as well as attempting to maximize different currencies, which include social and political motivations like avoiding conflict. For this reason, most applications of HBE have focused on hunter-gatherer groups and issues of food and sex (Mithen 1998). Typical HBE topics include foraging strategies, sexual division of labor, mating systems, altruism, food sharing, and fertility (Cronk et al. 2000). Using simple, logical mathematical models in concert with ethnographic observations, HBE has explored issues for small-scale human groups (Winterhalder and Smith 1999). HBE predicts that by the time of *Homo erectus,* female hominids evolved to live long after menopause because this allowed grandmothers to help care for their grandchildren, thus bettering the survival chances of their own kin (Hawkes et al. 1998; O'Connell et al. 1999). HBE has been extended toward horticultural systems (Keegan 1986) and theories of agricultural origins. Smith (1995) argues that domestication of plants and animals by hunter-gatherers began as a method of reducing risk. Smith makes subsistence risk the prime currency to be minimized in his model of Late Mesolithic hunter-gatherer behavior, while genetic changes in plants and animals serve as constraints that guided behaviors toward domestication.

EVOLUTIONARY PSYCHOLOGY

Evolutionary psychology (EP) takes the idea that behavioral flexibility evolved in hominids as an adaptation a step or two further than other approaches. EP takes as a starting assumptions that human cognitive abilities and behavioral tendencies evolved during the Plio-Pleistocene and that we can explain behavior since that point as the product of past evolutionary changes (Pinker 2002; Tooby and Cosmidies 1989). Research in cognition has shown that solving even simple cognitive tasks requires "innate" abilities that are complex in design and organization (Chomsky 1980, 1996; Fodor 1983; Pinker 2002) and thus can only be the product of long-term evolution, which, like parts of EA and HBE, can be tested through rigorous empirical research and hypothesis testing. EP assumes that over 3 million years as Plio-Pleistocene hominids existed within small kin-based groups with mobile foraging subsistence economies, human cognition evolved to reflect general solutions to characteristic problems. Just like a complex structure such as the eye, these evolved psychological mechanisms operate on complex tasks without conscious awareness (Tooby and Devore 1987), and further like the eye or the structure of the hand, are sufficiently complex that selection will not act on them over short evolutionary time.

EP bases many of is assumptions on psychological studies. For example, controlled studies revealing that people shown photographs of a variety of different natural landscapes generally prefer open woodland, savannas (Orians and Heerwagen 1992), suggest that this pan-cultural preference evolved on the African savanna. Other studies indicate gender-based differences in concepts of landscapes, in that women are better at remembering the spatial relationships among objects, while men generally have better long-distance mental maps (Silverman and Eals 1992). Because males hunt and women gather in most historically observed hunting and gathering societies, EPs argue that the male spatial ability is effective for hunting on a wide landscape, while the better local memory in females evolved for gathering plants from a relatively restricted area. If true, the implications for archaeology would be profound. For example, in regions where gathered foods are dominant, such as east Africa, site locations should be based on women's knowledge, with the opposite true in the Arctic where hunting provides nearly all energy (Maschner 1996b).

The goal of EP is to discover what algorithms exist in human cognition, and to explore how these mechanisms create and maintain cultural phenomena (Barkow 1989a; Cosmidies and Tooby 1987; Daly and Wilson 1997; Tooby and Cosmidies 1989; Tooby and DeVore 1987). In contrast with HBE, EP does not focus on the adaptive consequences of modern behaviors, and in fact does not assume that any behaviors in the modern world will be adaptive except by chance (Barkow 1989a; Tooby and Cosmidies 1989). Rather, proponents of EP suggest that we are all cognitively adapted to small, kin-based and mobile foraging groups and with the rise of more complex social forms, we can no longer be expected to behave adaptively because we are so far removed from our environment of evolutionary adaptiveness (EEA). With the rise of the Neolithic, for example, when humans first experienced multiple kin groups, sedentism, and a nonforaging economy, social change occurred at rates far faster than natural selection is able to track. Thus we have a Pleistocene psychology that was forced to deal with an urban social world that is often incongruous with our adaptive abilities (Tooby and Cosmidies 1989:35; Maschner 1996c).

Evolutionary psychology provides framework for the explanation of human behavioral evolution, for example, building on evidence for hard-wired, specialized intelligence modules in the human brain (Cosmedes and Tooby 1989:113; Gardner 1985; Mithen 1996). There are several versions of the modularity model. Pinker (2002) supports the massively modular conception which views the mind as being totally comprised of these modules each containing other modules which contain other modules and so forth in a hierarchical format. The moderately massive modular (Sterenly 2003) conception limits the amount of modules to specific domains;, what domains are modular, however, is contentious.

Plotkin (1994) situates evolutionary psychology in what he calls the secondary heuristic. The primary heuristic is genetic evolution which gave rise to the secondary heuristic or an evolving cognitive structure which in turn gives rise to the tertiary heuristic or culture and social reality. Each of these heuristics is linked to the other ones in both a feed forward and a feedback loop, that is, each heuristic was created by the previous one and created the following one. But once a heuristic gave rise to another heuristic, the latter heuristic then became part of the selection upon the previous heuristic (Plotkin 1994). In Dennett's (1995) words, evolutionary psychology is a crane—a tool with a foundation that allows us to lift other theories using it as a foundation.

EP Applications

Mithen (1996) argues that the development and subsequent integration of these distinct modules, which he categorized as natural history, social, technical, language, and general intelligences, was fundamental to the evolution of human behavior. The development of a particular module such as technical intelligence, for example, may explain the excellent skill of Neanderthals in making Levallois points, compared with their limited ability for language, if any. Revolutions in human behavior occurred when distinct intelligence modules became integrated. According to this model, the sudden proliferation of art in the Upper Paleolithic resulted from evolved communication between the social and natural history intelligences, which allowed abstract natural symbolism to be used for communication (Mithen 1996).

Sperber and Hirschfeld (2004) make an argument that certain aspects of not only intercultural similarity (as most evolutionary psychologists would claim) but also cultural differences and stability may be accountable by cognitive science and evolutionary psychology. They are quick to state that "we agree with standard social science that culture is not human psychology writ large and that it would make little sense to seek a psychological reductionist explanation of culture." However, they would like to see modularity taken into account as an (not the) engine for cultural differences and stability (two of the requirements for evolution). If modules are domain specific, then cultural representations may be anchored in particular modules or complex cultural manifestations such as religion may be anchored in several modules (Sperber and Hirschfeld 2004).

Another example of applied EP is Gil-White's (2001) argument that ethnic stereotyping is an outgrowth of our evolved capacity to differentiate natural species, such that we instinctively, unintentionally classify ethnic groups as different essences. Gil-White further argues that our tendency to socialize within our own ethnic group evolved as its own mental module, which was selected for because of the advantages to being well-versed in the operating social customs, and the tendency for social groups to punish those who do not conform. But it may simply be a product of in-group/out-group behavior, which provides the means to recognize those related to you versus those who are strangers.

While proponents of EP do not believe there is a mental module for every human behavior (contra Ehrlich 2000 and Gould 2000), we must be cautious of a sort of adaptationism (Gould and Lewontin 1979) and functionalism that Dennett (1995) refers to as the misguided "sky hook" idea that evolution pulls things toward an optimal design. Not every human behavior is adaptive, especially those with negligible or neutral consequences for reproduction. If we consider ethnic stereotypes to be a form of imagined kin groups (Jones 2000), there need be no specialized mental module for it, since the organisms are inclined by inclusive fitness to favor their own kin. A specialized ability for gossip may have evolved in females in competing for important social information concerning resources and mates (Barkow 1992; Dunbar 1996; Hess and Hagen 2002), but gossip could also have arisen naturally from information communication about all sorts of things, including the landscape, location of food resources, and so on.

Theological arguments aside, religion might result from our evolved instinct to acquire gossip about everyone else, and hence to envisage omniscient deities who communicate such information with us (Boyer 2001), or it could have no adaptive value at all, having emerged from the complex interaction of mental abilities—an accident of our evolution, a "spandrel" (Gould and Lewontin 1979). That said, evidence for the distinct existence or evolution of such evolved cognitive mechanisms leads to extraordinary explanative potential regarding human behavior. Support for the special evolution of gossip comes from the fact that girls gossip more competitively and aggressively than boys (Bjorkqvist et al. 1992; Eckert 1990; Eder and Hallihan 1978), the direct relevance of gossip to finding a reliable mate, and the prevalence of patrilocality in prehistory (Bentley et al. 2002; Seilestad et al. 1998;), which Hess and Hagen (2002) take to infer female competition.

Even in language, Lakoff and Johnson (1999) use evolutionary psychology as a foundation for their analysis of metaphors. To them many metaphors take on a spatial theme because the neurons used to negotiate physical space are likely the same ones that are used to navigate conceptual space and that our conceptual categories are also influenced by spatial categories and by virtue of our being neural beings. This type of analysis has implications for the social sciences that are not generally seen to be amenable to evolutionary psychology. With the ideas of Sperber and Hirschfeld (2004), Plotkin (1994), Lakoff and Johnson (1999), and a growing number of others, the social sciences are having a new engine for difference and similarity developed for them that will not replace any of the other equally important engines currently used for analysis. These type of studies will have powerful implications for understanding past social dynamics.

While discussing HBE, we noted that foraging theory tends to be less successful in explaining the economic behavior of more complex groups. EP gives us the mechanism for investigating this problem. If we have evolved mechanisms for living in small, mobile groups, cognitive modules that evolved over several million years on the African landscape, then the only modern groups who should exhibit cost effective foraging should be foragers, the groups closet to the environment of evolutionary adaptiveness (EEA). As we moved into villages with a number of unrelated people or kin groups, we would have had to create social mechanisms to adapt to these new conditions because these adaptive modules are too complex for natural selection to act on in the short term. Thus we would expect villages and others to develop social solutions to make up for the fact that we do not have the mental adaptations for living in the same place all year with a bunch of unrelated people. Thus we would expect villages and those in state-level societies to sacrifice foraging efficiency and maximize social and political efficiency, and this is indeed the case (Maschner 1992, 1996b).

EP can also solve the problem of altruism as well. As described in the next section, some evolutionary biologists have argued that altruistic behavior, beyond that of kin selection, may be evidence of group selection. But if the cognitive ability for kin selection developed in the context of kin-based groups and was reinforced over millions of years, then altruistic behavior to nonkin might just be an accident of history. For example, why do some people spontaneously put their life in jeopardy to save a random person in peril? The answer lies in the fact that for millions of years, there is a very good chance that this person would have been related in some why, thus satisfying the tenets of kin selection. But humans have only been consistently interacting with many unrelated people for a few thousand years, far too short for selection to act on such a complex trait. Thus, rather than group selection as a mechanism, perhaps many of our decisions are actually based on the fact that our decision-making abilities are built on millions of years of kin-based interactions, a condition that has not yet, been sufficiently investigated.

Many archaeologists over the past decade have used terms such as aggrandizers, status strivers, and chiefly thugs to frame new approaches to the rise of complex hunter-gatherers (Ames, chapter 28; Hayden 1998; Maschner 1992; Maschner and Reedy-Maschner 1998) that see status competition as critical to understanding these changing social dynamics. Evolutionary psychologists have been interested in our cognitive adaptations for status competition (Wrangham and Peterson 1996) and archaeologists are beginning to investigate the cognitive foundations for these behavioral assumptions (Maschner 1992; 1996b). Further, while many evolutionary psychologists are investigating our innate abilities, such as status striving, risk assessment, in group/out group behavior, kin selection and altruism, the ability to weigh costs and returns, and our innate skills at detecting cheaters, perhaps the more interesting aspects of behavior are those for which we have no innate abilities. These include living in complex social groups and religion, or those innate abilities that are manipulated to do other things, such as our ability to form fictive kin groups in order to go to war or to form academic archaeology departments. The social and political problems so prevalent in the modern world are just those issues for which evolutionary psychology can find no innate abilities. This is the fundamental reason why EP does not propose that any modern behaviors are adaptive (contra HBE), since we no longer live under any of the environmental conditions that created our innate abilities through natural selection (Barkow et al. 1992).

Evolutionary psychology in archaeology will not be tested directly. Rather, EP defines the limits, the boundaries, and creates expectation for how we would expect the past to look. Much like optimal foraging theory, it allows us to use it as a screen on which we can project the past. It further defines specific realms of behavior that we can in turn use as basic assumptions for investigating complex social phenomena.

COOPERATION AND MULTILEVEL SELECTION

One common position in evolutionary biology is that throughout evolution, natural selection has acted primarily on genes, which must replicate accurately and often, as well as last durably in order to survive. Multicellular organisms, including people, exist as survival machines evolved for the sole purpose preserving and transmitting their selfish genes (Dawkins 1976). In this view, the larger the unit of analysis gets from the scale of the gene, as with individual organisms, species, or even human groups, the more unlikely it becomes to consider natural selection acting on that unit. Selection on human groups is particularly problematic since it would seem that selfish individuals could always outcompete their cooperative neighbors by taking advantage of them. How then did altruism, cooperation, and social organizations develop? One way to resolve this, without sacrificing the selfish gene concept, is the idea of inclusive fitness (Hamilton 1964; cf. Maschner and Patton 1996 for an archaeological example)—even if the person carrying a gene does not survive, a gene can be passed into the next generation if the person's relatives (who carry many of the same genes) survive. The theory that caring grandmothers increase the survival chances of their own grandchildren (Hawkes et al. 1998; O'Connell et al. 1999), for example, is founded in the inclusive fitness concept.

While kin selection is useful in cases where there is strong relatedness among populations, it does not explain cooperation among unrelated individuals. One way in which this question has been addressed is through the use of mathematical game theory (Nash 1953; von Neumann and Morganstern 1944; Shennan 2002; Skyrms 1996). The classic example of game theory is the prisoner's dilemma, which involves two players who each decide whether or not to cooperate with authorities in efforts to minimize their own prison sentences. If neither criminal confesses, both go free; if one confesses, the other receives a stiff sentence; if both confess, they each receive moderate sentences. The dilemma is that fearing treachery, each informs on the other, yielding the worst possible outcome. This is known as the tragedy of the commons, examples of which include the ways humans from the Pleistocene to the present day have repeatedly overexploited their environment to the detriment of everyone (Alroy 2001; Hardin 1968; Jackson et al. 2001; Roberts et al. 2001).

The tragedy of the commons is avoidable if mutual cooperation always carries a higher benefit than defection, because in such cases there is no dilemma. Group selection is therefore possible when the interests of the individual coincide with the group (Shennan 2002; Williams and Williams 1957; Wilson 1998). For example, food sharing does not benefit the individual hunter directly, but it does benefit the hunter's group and therefore benefits the hunter indirectly with respect to groups of nonsharing hunters (Wilson 1998). In such cases, selection on the group level might be stronger than at the individual level, leading to the differential survival of groups with greater degrees of cooperation (Traulsen and Nowak 2006). At the individual level, this is still individual selection because the individual benefits from participation in the group and playing by the group's rules are critical to an individual's fitness. It gets interesting at the level of multiple competing groups where it is not only advantageous at the individual level, but where the group becomes an emergent entity as well, and then group-level selection might play a significant role.

Even with prisoner's dilemma and other games involving a logical temptation to defect, however, cooperation can emerge when they are played repeatedly among many interacting individuals. It is important whether or not each player retains a memory, which allows strategies that react to previous interactions (Cox et al. 1999). A surprisingly simple and successful strategy is tit-for tat (Axlerod 1984), by which an agent defects when its previous opponent defects, and cooperates when its previous opponent cooperates. If many players are allowed to play each other and live and die by these games, tit-for-tat emerges as an evolutionarily stable strategy; that is, it tends to win out over unstable alternatives as always defect and always cooperate. For example, if all players cooperate, then one cheater can defect on everyone it meets, winning every time and multiplying until defectors start to dominate the population, and everyone loses as the outcomes become the worst possible. Endless variations of games and strategies are possible but in general, strategies that involve reciprocity are evolutionarily stable—they cooperate when cooperated with in past encounters, or defect when mostly defected on (Bowles and Gintis 2000; Danielson 2002; Nowak and Sigmund 1998; Sethi and Somanthan 2001).

Cooperation can emerge even among selfish individuals without memory, in simulated games where individuals bear tags to identify those with similar strategies (Riolo et al. 2001). As a mechanism players use to discriminate us from them, tags might be viewed as a reversion to kin selection (Sigmund and Nowak 2001), but cultural tags lead to cooperation among unrelated individuals when the group has a system of strong reciprocity. In which nonconformists are punished and "normal" behavior is rewarded (Bowles and Gintis 2000; Henrich and Boyd 2001). Even among primates, aggression is constrained by the need to maintain beneficial relationships (de Waal 2000). Strong reciprocity may explain the evolution of prosocial traits—rules of conduct whose increased frequency in a population enhances the level of well-being of its members (Bowles and Gintis 2000). Controlled ethnographic experiments suggest that people in large and small-scale societies everywhere make economic deals based on social concepts of fairness rather than individual self-interest (Camerer 1997; Henrich et al. 2006; Roth et al. 1991). While evolutionary psychologists might see this as a kin-based trait transposed into the modern world, the end product is clearly an adaptation to living in complex social units far beyond the kin group.

Sober and Wilson (1998) have shown that multi-level selection can explain group-beneficial behaviors in situations where selection between groups overcomes the selection for selfish individual behaviors within each group. In many cases of multilevel selection, the spatial structure of groups can be enough to allow group-beneficial traits to increase overall within a population, even though there is selection for individuals who are selfish within each group. This surprising result derives from the benefits that cooperative individuals have on the overall success of groups (even though cooperation *is* self-interest). Altruism can persist and succeed despite the apparent benefits of selfishness. On this basis, any mechanisms that suppress variation within groups will enhance the efficacy of selection between groups and thus increase the likelihood that group-level behavior persists.

In this way, we can see that evolution can result in the selection for organization at a variety of levels: from simple redundant individuals, to the level of the herd where individuals benefit from some shared activity, to complex social groups where individuals are mutually dependent on one another. Future research will extend the quantitative model of multilevel selection to multiple groups using Price's covariance approach (Sober and Wilson 1998; Price 1970). This will enhance the explanatory power of the evolutionary model for situations in which group organization is clearly present and affecting the fitness of cultural entities.

CONCLUSION

> We know that going to the Moon was a simple task indeed, compared with some others we have set for ourselves, such as creating a humane society or a peaceful world.
>
> —Herbert Simon (1996:139)

While few archaeologists would profess to doubt the validity of evolutionary theory as a means for explaining our biological origins, there has been much debate over how and the degree to which evolutionary principles should be applied in archaeology (Bamforth 2002, 2003; Boone and Smith 1998; Kehoe 2000; Maschner 1996c,d, 2003; Maschner and Mithen 1996; Mithen 1998; Pauketat 2004; Schiffer 1996, 2004). The positions in this debate vary in form. Some researchers limit evolution to its effects in biological reproduction and suggest that human behavior is a product of evolution that occurred in the past (Mithen 1998). Some argue that if evolution is differential biological reproduction, then it cannot account for the fast, flexible adaptiveness of humans (Bamforth 2002, 2003). Others equate Darwinian change with transformational cultural evolution (Kehoe 2000) or concepts used for measures with real entities (Schiffer 2004). Still others reject explicit scientific goals and maintain the need for disciplinary heterogeneity (Hegmon 2003; Kehoe 2000; Pauketat 2004) or assert the primacy of human agency as the mechanism for change (Pauketat 2004; Schiffer 1996).

Although there is disagreement, all of the approaches outlined in this chapter share a goal of explaining the archaeological record, human history, and cultural change as the product of past or ongoing evolution. None of the approaches, however, is entirely adequate in terms of units for measurement, methods for generating expectations, clarity of language, dynamic completeness, and empirical sufficiency. We have yet, for example, to develop a good measure of the tolerance limits for our alternative hypotheses and are still deriving exemplars for what evolutionary explanations look like (Bettinger and Richerson 1996). Consequently, as documented in this chapter, the myriad of evolutionary approaches available to the archaeologist are often incompatible, competitive, and even hostile to one another. Some of these debates are at least partly semantic, demonstrating the need for mutually agreed definitions of terms such as "phenotype" and the need to cross the language barrier between approaches that often discuss very similar issues with different vocabulary (Mithen

1989); for instance, agency theory speaks of agency instead of intentionality and structuration rather than selection. Although there are differences in interpretation, more communication between the different approaches could only help; many of the other debates are profound and not unique to evolutionary science. Understanding the historical nature of human change brings up deep questions of how cognition works, as well as the philosophical foundations of science (Hull 1988) and archaeology (see Koerner and Price, chapter 21). These are healthy questions, and from an evolutionary perspective the variability of approaches is a good sign: it is the mark of a vibrant discipline generating variants along as many dimensions as possible as it makes it way down an evolutionary path leading to increasing explanatory power (Hull 1988; O'Brien et al. 2005). This is the way science works and if our goal is to build a science, this kind of diversity is expected (and desirable).

For example, HBE is often phrased as a competitive explanatory framework to EA and DIT (Boone and Smith 1998). HBE is not necessarily in conflict with other evolutionary approaches to the study of the archaeological record (Neff 2000). HBE provides a robust means for studying the fitness consequences of variability in the behavioral component of the human phenotype. Cannon (2000, 2001), for example, studied changes in faunal remains and subsistence activities among prehistoric populations of the Mimbres valley in the American Southwest and convincingly demonstrated that selection on resource returns resulted in a shift from hunting large mammals to cultivating plants. Cannon's study uses HBE models to develop fitness estimates for behavior under varying conditions. Similar to the study of the engineering performance of artifacts (Feathers 1990; Kornbacher 2001; Pierce 2005; Pfeffer 2001; Wilhelmsen 2001), HBE models allow one to develop expectations for how natural selection will favor variability in the behavior component of the phenotype (Maxwell 1995). In this way, HBE enables researchers to explain changes in trace fossils, artifacts that are not directly part of the phenotype but are produced by the interaction of phenotype and the environment.

In looking at the past twenty years or so, one might characterize EA, DIT, HBE, and EP with different goals and interpretations, as this chapter has described. Without a doubt they all offer insights into investigating the evolution of humanity in the context of genes, behaviors, decisions, or all in concert. It is important for the next generation of archaeological theorists to evaluate the pros of cons of these past approaches. One should not feel obligated to be an evolutionary archaeologist or a human behavioral ecologist per se, since these are just artificial disciplinary boundaries that emerged from the differences in past thought, and need not determine the direction of future theory. There are many ways of making use of evolutionary principles for generating explanations, each emphasizing different aspects of the underlying Darwinian framework. Ultimately, the question of what is "right" depends on what one is trying to explain and what is sufficient to account for the observed phenomenon. In this way, evolutionary science itself is a process of change, developing new hypotheses as new information becomes available. So for any newcomer to uncritically subscribe to the entire thought package of any one team is just feeble conformism.

Going forward, we can expect to see increased sophistication in evolutionary models that consider the effects of continuous transmission sorted by local processes creating variants that succeed differentially over time and space (Bentley et al. 2004; Bentley and Shennan 2003; Eerkens and Lipo 2005). We can expect to see greater use of genetics to study biological relatedness among prehistoric populations using trace remains of DNA (Jones 2003; Kimura et al. 2001; Newman et al. 2002) and the use of cladistics-based methods to trace relatedness among cultural variants (Lipo et al. 2005; Mace et al. 2005). We can also expect to see increasingly sophisticated models for studying the fitness of behavioral variants (Cannon 2003), new ways of understanding human cognition and its evolutionary origins (Barrett et al. 2002; Dorus et al. 2004; Dunbar 2003).

Just by addressing questions with evolutionary theory, we are able to frame questions about ourselves (e.g., human intentionality, the nature of cultural change, artifact variability) in a logical light, cleared as much as possible of the biases we have by being human. Evolutionary inquiries provide a means for studying aspects of ourselves in way that provide falsifiable accounts of the archaeological record. While the details are yet being worked out, what we can say with certainty is that archaeology which uses evolutionary explanations is likely emerge into a powerful and robust discipline. But we will never have a unified approach to Darwinism in archaeology until we all become simultaneously evolutionary archaeologists, human behavioral ecologists, evolutionary psychologists, and dual-inheritance theorists—in other words, stay focused on science as a fluid process of using all our information to build the best theories possible and resisting the very real (Surowiecki 2004) social tendency to divide ourselves narrowly into like-minded groups.

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